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HARMONICS

Harmonics affect power quality in both residential and commercial buildings and can cause serious malfunctioning and even damage to today's highly sophisticated electrical and electronic equipment. Electricians are committed to minimizing the risk of damage on a daily basis. Most of today's equipment requires clean, electric power. The equipment is highly sensitive to power distortions. Harmonic distortion is one of these. Harmonics can cause blinking of incandescent lights, flickering of fluorescent lights, computer malfunction, blowing fuses, or motor failure to name just a few problems.
In any electrical network, these harmonics cause an increase in system current, resulting in heating. This is one of the reasons for component malfunction. Consider solid-state semiconductors, induction motors, rectifiers, and any kind of discharge lamps as possible sources of these harmonics.

As an electrician, you face serious challenges with questions like:

1) What is harmonic distortion?
2) How can it be measured?
3) What causes harmonic distortion?
4) How can you prevent it?
5) What is the standard that guides you to know the limits of harmonic distortion?

Harmonics and harmonic distortion

In very simple terms, harmonics are voltage and current sinusoids that have different (multiple) frequencies in addition to the fundamental frequency of 50 hertz (Hz). The usual practice is to identify the harmonic waveforms by harmonic numbers. For example, we call the third harmonic as a sinusoid with a frequency of 150 Hz (3 x 50 Hz) and the fifth harmonic as a sinusoid with a frequency of 250 Hz (5 x 50 Hz). Figure 1 shows fundamental, third harmonic, and fifth harmonic. In the presence of these harmonics, the amplitude of the alternating current (AC) voltage waveform changes (shown in red, see Figure 2 (a)). As you can see, the harmonics cause harmonic distortion. Mathematically, we represent total harmonic distortion (THD) as

$$\%Vthd = \frac{\sqrt{[\left(2v^2 + 3v^2 + 4v^2 + 5v^2 + \cdots nv^2\right)]}}{v^{t}}$$

Where v: RMS voltage for each harmonic, v^{t} : total RMS voltage.
Note: THD also applies to current and power waveform.

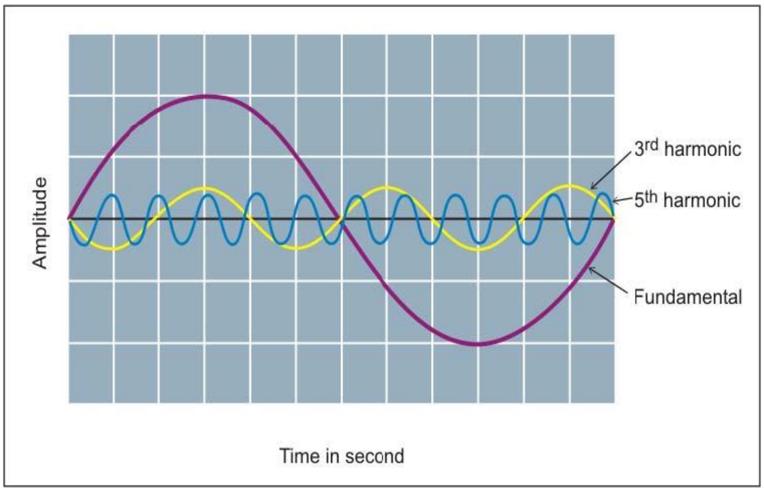

Figure 1

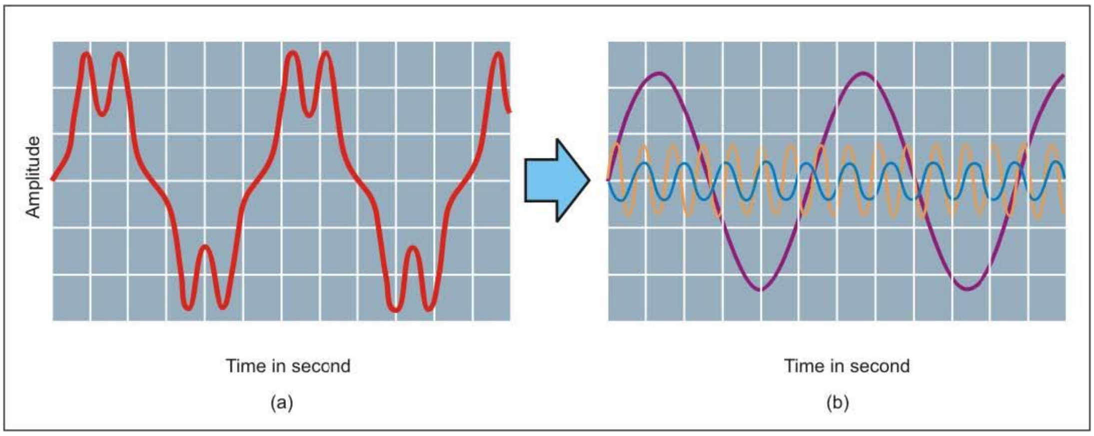

Figure 2

What causes harmonic distortion?

In any electrical circuit, the main reason for harmonics is the presence of a non-linear, electrical load. By the term "non-linear load", we refer to a load that does not have constant impedance. For most AC power systems, the voltage variation follows a sinusoidal wave form. The subsequent current is sinusoid if the circuit consists of resistive and inductive loads. However, when the circuit has a non-linear load, harmonics are created and the current does not follow the voltage smoothly in the electrical circuit.

Here are few examples of non-linear loads that can create harmonic distortion:

- Motors and transformers
- Arc furnaces
- Semiconductor power control and conversion

As a result of using a non-linear load, often the current is switched off or on, and a pulse is created. A pulse consists of a spectrum of harmonic frequencies with a 50 Hz fundamental and multiples of it.

Note that non-linear loads have both high and low impedance for the applied voltage. When low impedance is applied to the voltage source, large current flows. The opposite happens when high impedance is applied resulting in a smaller current.

How can you measure harmonic distortion?

As an electrician, you must measure harmonic distortion in a power system, whether it is for residential houses or commercial buildings. You can do this by measuring voltage and current with true RMS (root-means-square) digital meters. This helps you to estimate the harmonic distortion for all practical purposes. Note: An average-responding RMS meter does not provide an acceptable result.

For accurate measurement of harmonic distortion, you can use spectrum analysers or harmonic analysers, in addition to an oscilloscope or a power disturbance monitor. These meters/monitors display harmonic waveforms via graphs and are highly suited for accurate calculations. You can also identify an overheated connection in panel board or in a transformer because of harmonic distortion, by using infrared meters.

The other practices for identifying the problems of harmonic distortion are:

a) You should visually inspect components under the panel cover for any evidence of overheating, discoloration, or insulation breakdowns.

b) You can measure the neutral current at the transformer's secondary. Neutral current should never exceed 70 percent of the conductor's rated capacity.

c) You can measure the temperature of the transformer. It should not exceed the nameplate temperature rise with a load that is less than the capacity rating.

Know the Specification

As an electrician, you should know more about the limits imposed by utilities on harmonic distortion via "National Regulators Specification 048 Part 2.

For example, the specified voltage THD distortion should not exceed 8%.

How can you prevent or take remedial measures for harmonic distortion?

As an electrician, you can only minimize the effects of harmonic distortion. Each approach you undertake has its own effectiveness and efficiency. See Figure 3 for a variety of approaches. Before a user is affected by harmonic distortion in a commercial or residential building, you can deal with the ensuing problem by such preventative measures as:

- Fix poor grounding that exists for individual equipment or for the entire facility.
- Move loads between branch circuits or add additional circuits for isolating any kind of sensitive equipment.
- Use larger-sized neutral wire, or install a separate wire for neutral wires for each phase, or use oversized or K-rated transformers.
- Use harmonic-rated circuit breakers and panels that can withstand overheating because of harmonics.

In addition, you can take several remedial measures by using passive harmonic filters, isolation transformers, harmonic mitigating transformers, and active filters.

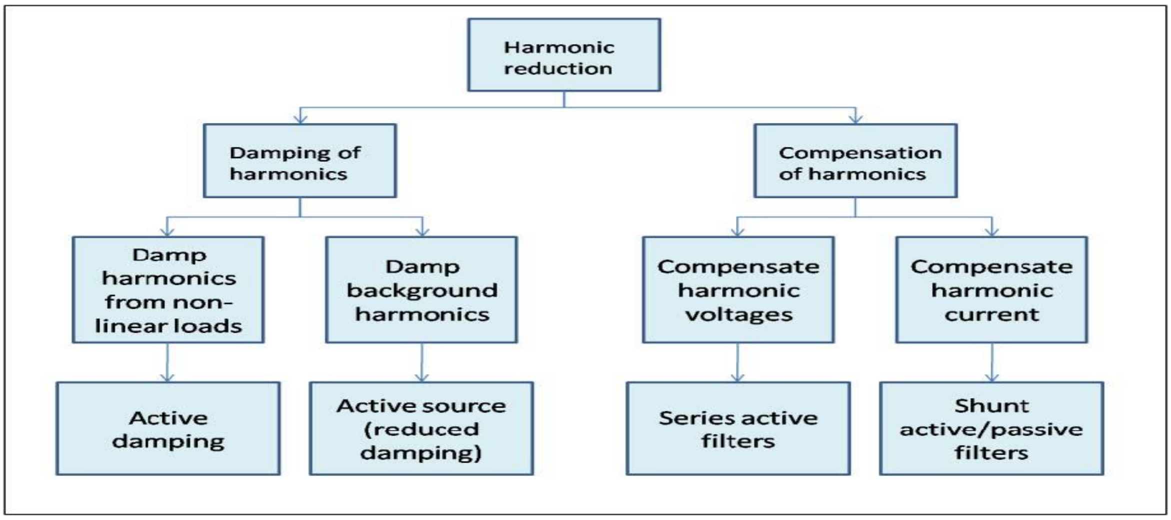

Figure 3

Example:

Use a filter as shown in the following Figure 4. This filter has a capacitor for each harmonic frequency where capacitors are connected in series with individual reactors. This simple filter can ensure a very small amount of harmonic current for your electrical network.

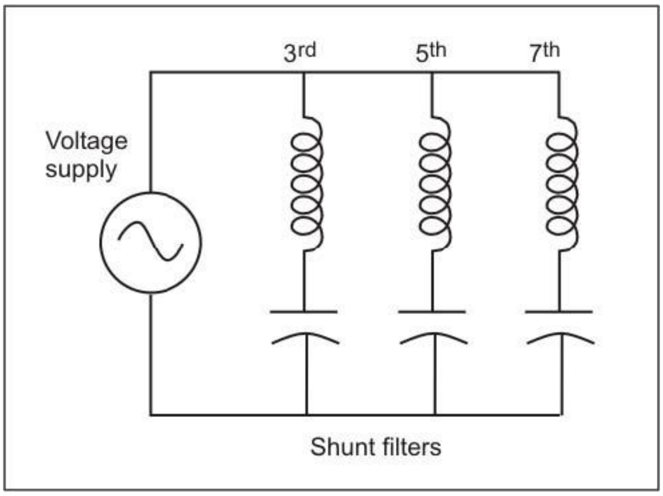

Figure 4